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DRAWINGS ATTACHED

1 302 644

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(71) We, GTE SYLVANIA INCORPORATED, a Corporation organized and existing under the laws of the State of Delaware, United States of America, of 100, West 10th Street, Wilmington, Delaware, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to broadband multi-element antennas or aerial arrays.

Installation of television antennas on the roofs of dwellings in an effort to improve signal reception has several disadvantages. The maze of vertical masts and horizontal elements above the rooftops in suburban neighbourhoods is fast becoming or has already become a general eyesore. The height of the antenna above the roof and the guy wires it requires vary from home to home and from neighbourhood to neighbourhood depending on the number and distance of stations sought to be received. The exposure of such antennas to the elements makes them susceptible to damage and deterioration; the higher the antenna, the greater is the likelihood that it will be blown down. The physical length or bulk of broadband antennas further complicates installation and requires additional reinforcement to stabilize the extra mass. In addition, the installation of the rooftop antenna can be dangerous for the do-it-yourself homeowner or costly for him if he engages a skilled technician.

In the past, a directional television antenna such as a log-periodic array has been adapted to reception of signals from widely dispersed broadcast transmitters by use of a rotatable mast, a self synchronous motor to rotate the mast, and an indoor control to operate the motor and point the antenna in the direction of the desired station transmitter. Such equipment is not only expensive and difficult to install, but it is also cumbersome to operate when the television viewer is in the process of selecting a programme to be viewed.

According to the invention there is provided a multi-element antenna array comprising a plurality of antenna sections for receiving signals in as many frequency bands, each section having an electrical axis and including a pair of juxtaposed axially extending transmission lines, a plurality of antenna elements extending in directions transverse to the said axis and connected to the transmission lines, and means for detachably coupling the sections together and for thereby electrically connecting the transmission lines in series.

In one embodiment a broadband FM-VHF-UHF antenna is made in three sections on light-weight flexible plastics sheets detachably connectable together to provide electrical continuity over the reception band. The strip conductors are preformed on the sheets so that the only assembly operation required is snap-fastening the sections together and suspending them like a banner in a room or attic. The extremely low weight per unit length of this structure and its sectionalized furlable construction enable in-house installation of an antenna having an electrical length (gain) that more than compensates for the lower elevation compared to exterior mast-mounted antennas. The physical separateness of the antenna sections which respectively respond to discrete portions of the reception band permits different physical orientation of the electrically series-connected sections so that each section may be pointed in the direction of broadcast transmitters to which it is tuned.

The invention will now be described in more detail, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of a dwelling, partially broken away to show the installation in its attic of an antenna embodying this invention.

Figure 2 is a perspective view of the com-

pletely rolled-up antenna partially inserted into a storage container;

Figure 3 is a perspective view of a partially rolled-up antenna;

Figure 4 is a plan schematic view of an entire UHF-VHF-FM antenna embodying this invention with the separate sections directly connected to each other;

Figure 5 is an enlarged fragmentary plan view of the antenna of Figure 4 showing details of construction.

Figure 6 is an enlarged fragmentary section of the antenna taken on line 6—6 of Figure 5.

Figure 7 is a similar transverse section taken on line 7—7 of Figure 5 showing the snap fastener connections between feed lines of the adjacent sections.

Figure 8 is a section taken on line 8—8 of Figure 5 showing an adapter for connection of the antenna to external feed lines.

Figure 9 is a transverse section taken on line 9—9 of Figure 8.

Figure 10 is a perspective view of an adapter-balun for connection of a coaxial feed line to the balanced feed line of the antenna; and

Figure 11 is a schematic plan view of the antenna sections pointing in different directions for receiving signals from widely dispersed transmitters.

Referring now to the drawings, a furlable antenna embodying this invention is shown in general at 10 in the furled or rolled-up position for storage in a cylindrical container 11, see Figure 2, in the partially unfurled and disconnected condition as shown in Figure 3 preparatory to installation, and in an installed operative position in the attic A of house H as shown in Figure 1. Antenna 10 in the operative position is a substantially planar multiple element array preferably of log periodic design adapted to receive horizontally polarized signals, and therefore is hung from the rafters R of the attic roof by string S or the like connected to the four corners of the integrated sheet which is suspended in a substantially horizontal plane as shown. Connection of the antenna to a television receiver T or the like is made by lines L extending from the antenna to the receiver. While it is recommended or preferred that the antenna be installed at the highest elevation possible within the protected enclosure for optimizing reception from remote transmitters, it will be understood that advantages of this antenna construction to be described in detail below may also be realized from installation of the antenna in other rooms within the building including first floor rooms. This is especially true when the receiver is located in a strong signal environment.

Antenna 10 is shown in the operative position in Figure 4 and comprises three physically separate sections 13, 14 and 15 designed to receive electromagnetic wave signals in separate bands as follows:

Section 13: UHF — 470 to 890 MHz
Section 14: High VHF — 174 to 216 MHz
Section 15: Low VHF and FM — 54 to 108 MHz

Sections 13 and 14 are substantially identical in construction, except for size, each having a pair of longitudinally extending parallel transmission lines 17 and 18 formed on one side of a plastics trapezoidally-shaped sheet 19, axially spaced transversely extending dipoles 20 also formed on the same side of the sheet, and transverse axially spaced parasitic elements 21 formed on the opposite side of the sheet with predetermined axial spacings from adjacent dipoles. Elements of the dipoles on the same side of the antenna axis X are connected to the same one of the two transmission lines. Section 15 of the antenna is formed without parasitic elements and has transmission line 17^1 formed on one side of sheet 19^1 and the other transmission line 18^1 on the opposite or back side of the sheet. For this section 15, successive dipole elements 20^1 on one side of sheet 19^1, the top side as viewed in Figure 4, are alternately disposed on opposite sides of the axis and are electrically connected to the transmission line 17^1 on that side as shown, whereas the elements 20^{11} on the backside of the sheet are connected to line 18^1. Since the sheets 19 of the antenna sections are relatively thin, in the order of 0.002", all of the antenna elements are substantially in the same plane when the three-section assembly is suspended in the operative position.

The lengths and axial spacings of the dipoles in section 15 vary in accordance with the logarithmically periodic constant τ, as is well known in the art. Dipole elements 20 in sections 13 and 14 comprise a succession or series of cells of a Yagi-Uda array, each complete cell including a driven element, a reflector and a director. The size and spacings of the elements of the cells are related to each other in such a manner as to achieve the required and desired electrical length of the antenna for maximum gain, front to back ratio and pattern uniformity without superimposing one cell upon the other. This Yagi-Uda cell array is exemplary of an antenna design providing a high gain per unit length and one that may be advantageously used in practice; such antenna design is more fully described in U.S. Patent No. 3,530,484. Other plane multi-element arrays may also be used with advantage achieving a high gain by practicably increasing the

overall electrical length of the antenna to at least an extent required to offset whatever diminution of received signal intensity occurs as a consequence of mounting the array in the attic rather than on top of an outside mast.

It should be noted that while antenna sections 13, 14 and 15 receive signals in frequency separated bands, respectively, of the total broadcast spectrum recited above, these sections are readily integrated into one unitary antenna connected in electrical and axial series as shown in Figure 4 for high performance over the entire band. On the other hand, the individual antenna sections are independently responsive to signals in their respective bands and are physically separable from each other while electrically connectable in series so as to have their electrical axes oriented in different directions and operated as three separate antennas.

The material comprising the sheets of each of sections 13, 14 and 15 is non-conductive and flexible and may, for example, be vinyl impregnated nylon. The conductors which comprise the dipole and parasitic elements as well as the transmission lines may be formed on this sheet material by rolling, printing, painting or otherwise depositing metallic strips or layers in the form of foil, paint or the like by high speed apparatus similar to that used in printing wallpaper. These conductors are sufficiently thin, i.e., approximately 0.001″ thick, so as to be sufficiently flexible to assume the contour of the sheet when rolled or unrolled without fracturing or otherwise developing discontinuities that might adversely affect the operation of the antenna. Thus the conductors on each of the sections of the antenna may be applied by mass production techniques to achieve a low cost construction without sacrificing accuracy in the length, width or spacings of the elements or transmission lines.

As shown more clearly in Figure 5, the opposite marginal end portions of section 14 overlap the adjacent ends of sections 13 and 15, respectively. In order to removably or detachably mechanically connect the overlapped portions of the antenna sections together in longitudinal or axial series, a plurality of snap fasteners 23 are mounted adjacent opposite edges of the antenna sections. These snap fasteners may be of standard commercial construction and comprise a male portion 23*a* and a female portion 23*b*, see Figure 7, secured to the respective portions of the sheets to be attached and connectable by simply manually squeezing the parts together. Transmission lines 17 and 18 of the antenna sections are both mechanically and electrically connected together by such snap fasteners, the mating parts of which extend through and engage the respective transmission lines as well as the base sheet material of the section. In order to ensure electrical continuity at these connections, two snap fasteners for each transmission line connection are used as shown in Figure 5.

Each of the antenna sections 13, 14 and 15 is provided with eyelets 25 at the four corners of the section. This permits one or more of the sections to be suspended by strings, cords or the like from overhead supports such as the rafters in the attic. In order to connect transmission lines 17 and 18 to the television receiver, an adapter 27, see Figures 5, 8 and 9, comprising a dielectric board 28 is secured by integrated snap fasteners 29 to the transmission lines 17 and 18 at the end of antenna section 13. L-shaped connector terminals 31 and 32 project upwardly from board 28 and are electrically and mechanically connected to the parts of the fasteners 29 which extend through the board. In this manner terminals 31 and 32 are electrically connected to transmission lines 17 and 18 of antenna section 13 and provide convenient upright tabs for connecting lines L to the television receiver.

If it is desired to connect the antenna to the receiver by a coaxial line, an adapter 35 of the type shown in Figure 10 is used. This adapter comprises a pair of dielectric plates 36 and 37, one of which (plate 36) has parts of snap fasteners 38 and 39 secured thereto and projecting therefrom for connection to the mating parts of the snap fasteners on transmission lines 17 and 18. The outer and inner conductors of coaxial line connector 40 are electrically connected to snap fasteners 38 and 39 by means of a balun transformer 41 which is designed to match the impedance of the coaxial line to that of transmission lines 17 and 18. Balun transformer 41 is sandwiched between plates 36 and 37 which may be permanently secured together.

While in the above described embodiment of the invention adapters 27 and 35 are shown as connected to the high frequency end of antenna section 13, it will be understood that these adapters may also be used to connect receiver lines to each of antenna sections 14 and 15 as desired so as to permit any one or combination of the antenna sections to be operatively connected to the receiver.

It will be seen from the foregoing description that the antenna construction permits the user to select the particular frequency band or bands for which he desires reception and to readily install one or more of these sections by suspending the antenna from its corners. This antenna construction is adapted to improve reception of signals from transmitters that are geographically located

at widely divergent angles from the point of reception. This feature is schematically illustrated in Figure 11 wherein the outlines of sections 13, 14 and 15 are shown connected in electrical series by adapter cables 43 and 44, respectively, while the sections are physically spaced from one another and are oriented with their electrical axes, X_1, X_2 and X_3, respectively, pointed in different directions as indicated by the arrows. Cables 43 and 44 are connected to the transmission lines of adjacent antenna sections by means of adapters 27^1 utilizing snap fasteners as described above. Each of the antenna sections is suspended separately from the rafters with its axis pointing in a direction toward the transmitter or transmitters broadcasting in the band to which that antenna section is tuned. Thus this multi-section antenna not only provides high gain reception of signals over the entire band but it also is directionally adjustable to further optimize reception from different directions.

WHAT WE CLAIM IS:—

1. A multi-element antenna array comprising a plurality of antenna sections for receiving signals in as many frequency bands, each section having an electrical axis and including a pair of juxtaposed axially extending transmission lines, a plurality of antenna elements extending in directions transverse to the said axis and connected to the transmission lines, and means for detachably coupling the sections together and for thereby electrically connecting the transmission lines in series.

2. An array according to claim 1, in which the marginal end portions of adjacent sections overlap, and the axes of the sections are aligned.

3. An array according to claim 1, in which the axes of at least two of said sections extend in different directions.

4. An array according to claim 3, in which the two sections are physically separated, the coupling means comprising a pair of flexible conductors connected at opposite ends to the transmission lines on the two sections.

5. An array according to claim 4, in which the coupling means includes snap fasteners.

6. An array according to claim 1 or 2, in which the coupling means comprises fastener means attached to at least one axial end of each section for releasably interconnecting with mating fastener means on an adjacent section.

7. An array according to claim 6, in which the fastener means are attached to the transmission lines.

8. An array according to claim 6 or 7, in which the fastener means consist of snap fasteners.

9. An array according to any of the preceding claims, in which each of the antenna sections comprise a furlable dielectric sheet, the transmission lines and antenna elements being thin conductive elements formed on the sheet and furlable therewith.

10. An array according to any of the preceding claims, in which the antenna elements comprise dipoles having two elements connected to respective ones of the transmission lines.

11. A multi-element antenna array constructed and arranged substantially as herein described with reference to and as shown in the accompanying drawings.

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1302644 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

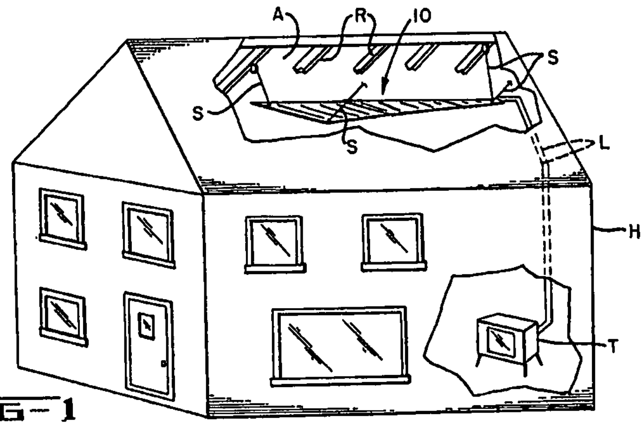

FIG-1

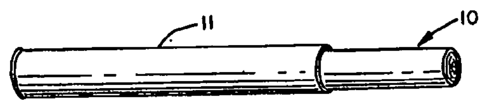

FIG-2

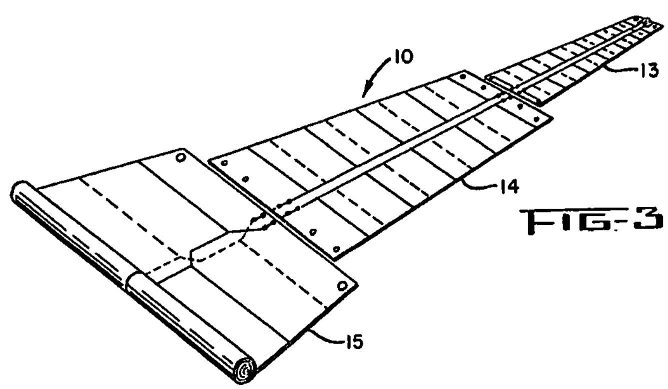

FIG-3

1302644 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

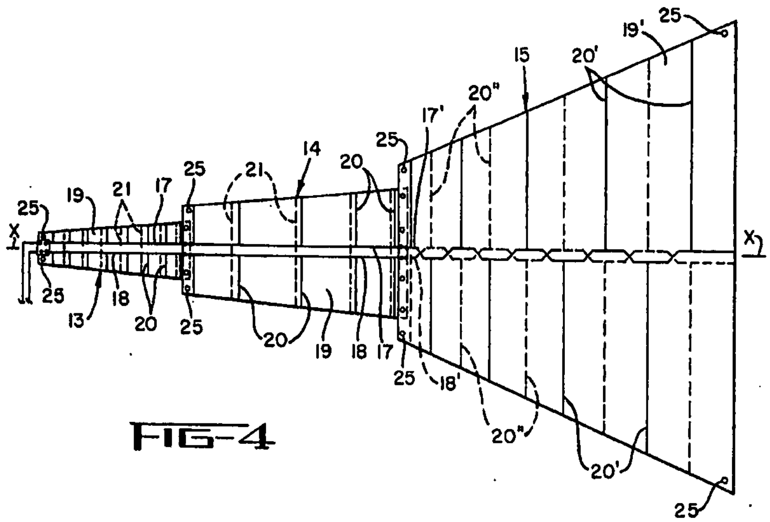

FIG-4

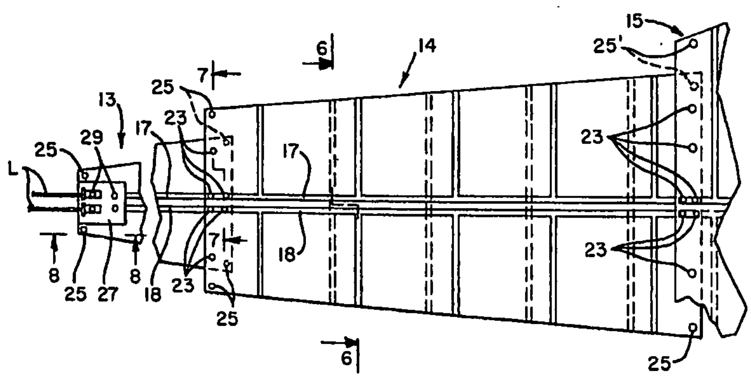

FIG-5

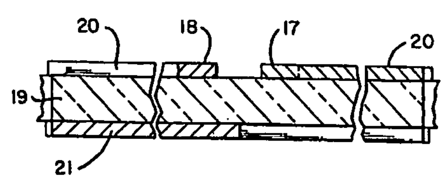

FIG-6

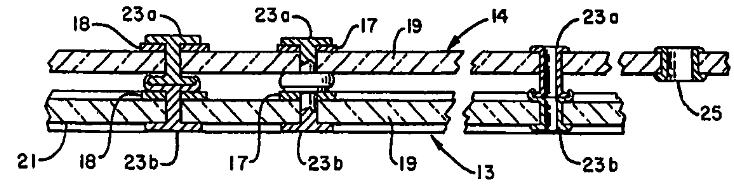

FIG-7

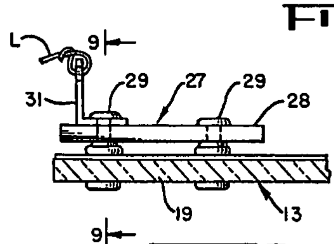

FIG-8

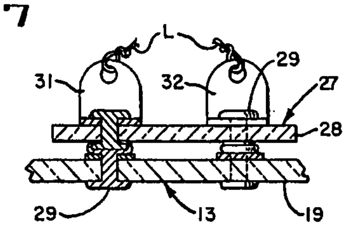

FIG-9

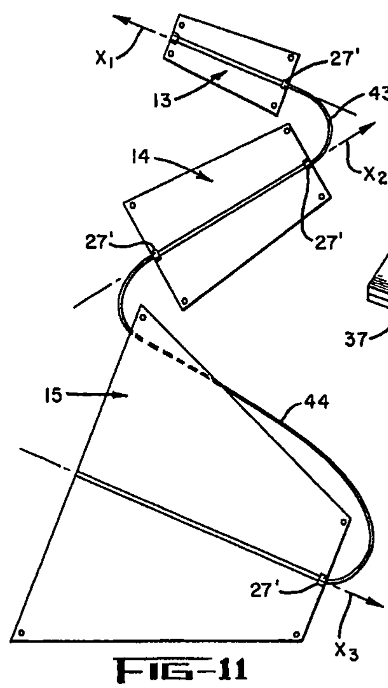

FIG-11

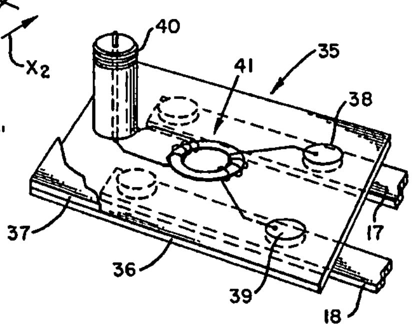

FIG-10